MASTER Internship / PhD project:

Ultrafast spectroscopy of bio-mimetic photoswitches - towards rational design

Supervisor : Pr. Stefan Haacke
Institut de Physique et Chimie des Matériaux de Strasbourg, IPCMS (ZRR)
Département d'Optique ultrarapide et Nanophotonique (DON)
Tel : +33 (0)6 25 93 51 46.
E-mail : stefan.haacke@ipcms.unistra.fr

Photoswitches are molecules, which after absorption of light, change their chemical structure and hence their "color" /absorption spectrum. Many examples exist for organic photoswitches, also in Nature, where photo-switching is very useful for biological processes like vision or light-dependent protein expression (plant growth). **FEMTO-Switch** is a new French-German project, involving research teams in Berlin, Strasbourg, Marseille, and Uppsala (Sweden). We combine our experimental and theoretical know-how for the investigation of organic photoswitches mimicking the ultrafast photoisomerization of retinal pigments of vision (rhodopsins). The main objective of the FEMTO-Switch project is to establish **rational bases between the chemical structure and the ultrafast dynamics of excited states**, in particular at conical intersections (Cint, cf. figure 1). According to many quantum mechanical simulations, these intersections between molecular potential energy surfaces ultimately determine the **quantum yields** of photoswitch reactions, the probability of reaching the product points P1 or P2 in fig. 1. Finding rational principles to enhance these quantum yields by chemical design would have large impacts for important applications in photoswitching of nanomaterials, in molecular motors and in photopharmacology.

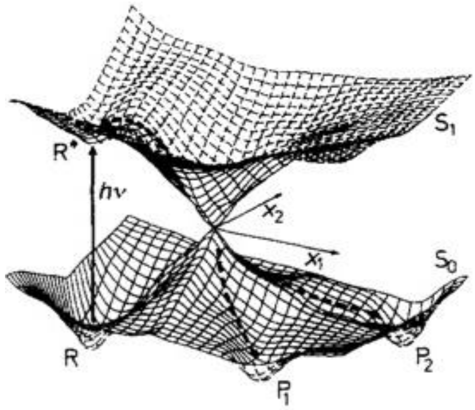

Figure 1: *Schematic of a conical intersection – crossing of the potential energy surfaces of S_0 and S_1, along to coordinates of molecular motion/vibration x_1 and x_2. From « Excited States and Photochemistry of Organic Molecules », M. Kiessinger & J. Michl (Wiley ed.)*

In the BIODYN team at IPCMS (University of Strasbourg-CNRS), led by J. Léonard, A. Boyer & S. Haacke, we study the details of the photo-isomerization reaction in small rhodopsin-mimicking photo-switches and motors [1-3], which are presently being used for photo-regulating the expression of DNA. We use femtosecond transient absorption, and fluorescence spectroscopy, in order to detect the effect of chemical substitutions on the speed and efficiency of the photo-reactions.

The internship breaks down in the following phases:

- Feb-March 2026: Training with the concepts and experimental tools of femtosecond spectroscopy. Introduction to data analysis.
- April-May: Extensive experimental studies of retinal Schiff bases in different solvents, and as a function of temperature.
- June: Data analysis and report writing.

After a successful master project, the internship will lead to a 3-year fully funded PhD project, including the chem. synthesis of switches

[1] M. Gueye et al. Nature Comm. **9**, 313 (2018) ; http://www.nature.com/articles/s41467-017-02668-w
[2] M. Filatov et al., Nature Comm. **13**, 6433 (2022) ; https://www.nature.com/articles/s41467-022-33695-x
[3] M. Mgbukwu et al., J. Phys. Chem. B, **129**, 3839 (2025) ; https://doi.org/10.1021/acs.jpcb.4c06856